elytra there are three or four longitudinal rows of tubercles of a larger size: on the suture and at the commencement of the apical third of the elytra is a tubercle which is provided with a tuft of small hairs: the body beneath is pitchy red; the upper parts are of a dull red colour. In some specimens small scattered green scales are observable on the thorax and elytra, especially on the sides of the former, and at the base and on the sides of the latter.

[To be continued.]

XXXVI.—*The Physical Agents of Temperature, Humidity, Light, and Soil, considered as developing Climate, and in connexion with Geographic Botany.* By RICHARD BRINSLEY HINDS, Esq., Surgeon R.N.

[Continued from p. 189.]

HITHERTO our attention has been chiefly directed to the temperature of the air, under the influence of various circumstances which regulate the amount. The direct heating power of the sun's rays, or radiation, has not been noticed, though their action on the vegetable kingdom is often very important. As vegetation under usual circumstances is fully exposed to the effects of the seasons, the conditions to which it is liable, from the presence or absence of the sun, become a subject of important inquiry. Two different results follow radiation: the first is an increase in the sensible heat during the period of the sun's rays above the horizon; the second is a decrease of the same, due to a transfer of heat during the night from the earth, by what is called terrestrial radiation. By this the temperature around vegetation is capable of being very considerably reduced.

I. Daily observation shows us the very great difference between the impression made on our feelings by the temperature of the shade and the sun's rays. The fact ascertained, it was next necessary to discover whether it obeyed any regularity in its relation to the temperature conferred on the air by the sun, and whether the progression of the seasons, time of the day, or the latitude, influenced this relation. The laws of its influence over the surface of the globe are now generally determined, and they become another confirmation of that omnipotent foresight by which the conditions of our nature were so distributed, that where at first view the absence of an agent would convey a momentary impression of error or confusion, a little inspection will display a new agent compensating for the absence of the other.

Its relations in different latitudes are not perhaps what would have been anticipated, since the power of the sun's rays over the temperature advances inversely to the mean heat. In low latitudes, and with a high annual mean, the difference is less than in high latitudes where the annual mean is low. In Mr. Daniel's Essays some observations on this subject are given which clearly prove this; and further, it appears, by some synchronous observations, that in the month of June, when the sun's rays were 47° above the air at Bahia, they were 65° in England. Connecting these with the polar regions, it was found that in the month of March, when in England the power of radiation was 49°, at Melville Island it was 55°. As none of the details given show any regular progression through different parallels, I obtained the materials for the following table; the observations were chiefly taken at sea, but always on board ship, where local influences are less numerous than on shore, and far more uniform.

Latitude.	Sun's Altitude.	Temp. of Shade.	Sun's Rays.	Difference.	State of the Weather.
° ′	° ′	°	°	°	
0 26	77 30	80·5	120·5	40	Atmosphere clear and fine.
5 56	69 4	80·5	111	30·5	Clear and fine: a fresh breeze.
8 8	66 29	80·5	107	26·5	Cloudless: a moderate breeze.
13	61 5	78	104	26	Clear: a fresh breeze.
17 47	55 44	75·5	109·5	34	Clear: a light breeze.
20 59	51 10	75	102	27	Clear: a light breeze.
21 34	48 53	74·5	107	32·5	Clear and fine: a calm.
33 9	48 10	70	112	42	Clear: a light breeze.
44 27	68 41	66	118	52	Light fleecy clouds: a calm.
46 19		66	108	42	Clear: a moderate breeze.
46 19		77	119	42	Clear: nearly calm.

In pursuance of the established fact, that many causes of climate are affected very similarly on elevation as in increasing the latitude, experiments were next made to ascertain the laws of radiation in the former. By those of Major Sabine, at a height of 4000 feet in the island of Jamaica, the force of radiation was 57°, being a much greater intensity than was observed at the level of the sea. Saussure observed that the power of the sun's rays was greater in elevated stations on the Alps than on the plains below. He at that time could not possibly appreciate the value that meteorologists would, at some subsequent period, place on such data; they were then but a fragment of the mass of irregular information which great and industrious minds are always accumulating, and which at some future day find an appropriation, whilst they also become an answer to the sceptic who is continually exclaiming "*cui bono*?" at every addition to our knowledge.

Among the Himma-leh mountains Mr. Royle considers he has obtained results similar to those of Saussure, inferred from the small deposition of snow in some localities, and its very speedy removal.

By radiation*, then, the depression of temperature in high latitudes and on ascent is in some measure counteracted, since the temperature of radiation and of the atmosphere are inversely different. The former carries with it light, and its operation is powerful for a time, as in the polar regions, where its duration is considerable; and on high mountain chains, where it bursts through the rarefied air, and lasting only for a few hours disappears. Can any circumstances of difference in polar and alpine floras be traced to this? The most probable answer will be found in the duration of life among plants of the same species growing naturally in both regions, or by a comparison between two nearly allied species of the same genus. Any inquiry on this subject should be directed to the periods occupied from the fall of the seed to germination, thence to flowering, to defloration, and to the shedding of the seeds.

Many circumstances are continually developed which must be attributed to the power of radiation, though, being so closely connected with light, the latter must be allowed a portion of the agency. Plants transferred from bright clear climates lose much of the brilliancy of their colours in a clouded one like our own; many of our garden favourites have thus

* In experiments on radiation the bulb of the thermometer exposed to the sun's rays is covered with cotton or wool dyed black, and the instrument is fixed on a surface admitting free movement in two directions, vertically and sideways, thus allowing the thermometer to be placed at all times to receive the direct rays. To ensure this more completely, a style about two inches long is attached, and when the surface is so moved that this throws no shade, the sun's rays impinge directly on the covered bulb. The bulb may be covered with black paint, or any other substance of this colour, and it is to be regretted that a particular material has not been generally adopted. Another thermometer for comparison should be placed in an unexceptionable situation in the shade.

The amount of radiation varies so rapidly from trifling causes, that it is very necessary to register the exact circumstances under which the experiments are conducted. A small difference in inclination—a passing cloud over the sun—the accession of a breeze—may make a difference of some degrees. Sometimes the thermometer is placed in a tube of white paper, which also has an important influence. I have also observed, that after a short exposure the mercury rises to a certain height and soon falls again two or three degrees. I believe this to be invariable, and must be attributed to the unequal expansion of the mercury and the glass at the commencement of the observation. It is therefore requisite to wait till the mercury has become settled to a certain point before the instrument is read off. No observations require more minute attention or a greater regard to circumstances than those of radiation.

but a remnant of their proper beauty. James, among the Rocky Mountains, observed the colours of the flowers to be surpassingly brilliant; the usual weather of the year was also proportionately transparent. With us, in clouded and dull summers, fruits and corn do not ripen with anything approaching the rapidity they otherwise would. The whole progress of the fruit is thus aided or retarded, from the setting to perfect maturation, and on it the flavour of edible kinds entirely depends. No latitudes produce flowers of greater richness of colouring than the warmer temperate regions; here cloudless weather prevails a greater part of the year; an Italian sky has become proverbial, and such a sky is found in similar latitudes all over the world. From Chili and California many of our most favourite ornamental flowers have found their way; the former has lovely species of *Fuchsia, Calceolaria, Lobelia, Escallonia,* and *Loranthus*; in California abound *Clarkia, Eschscholtzia, Vauchneria,* some very glowing species of *Ribes, Ceanothus,* and *Lupinus,* and others equally attractive; indeed both abound in beautiful flowers. It would be needless to mention the vegetable beauties of the Cape of Good Hope which revel in a similar climate.

II. Vegetation is subject to a proportionately reduced temperature from the agency of terrestrial radiation. Dr. Wells found, that a thermometer placed among growing plants fell during the night many degrees below the air, and on some occasions the difference amounted to as much as eleven degrees. Like solar radiation it is influenced by latitude and elevation, and seasons also have a controlling power. The depressions arising from these have been accurately observed by Mr. Daniell for each month of the year in our own climate, and his results for a period of three years are contained in the table.

Month.	Mean minimum of the Air.	Mean depression from radiation.	Maximum depression from radiation.	Month.	Mean minimum of the Air.	Mean depression from radiation.	Maximum depression from radiation.
January...	33°·6	3°·5	10°	July	52°·1	3°·6	13°
February..	33·7	4·7	10	August ...	52·9	5·2	12
March	37·7	5·5	10	September	50·1	5·2	13
April	42·2	6·2	14	October ...	42·1	4·8	11
May	45·1	4·2	13	November.	38·3	3·6	10
June	48·1	5·2	17	December.	35·4	3·5	11

Here there is a depression surpassing that of Dr. Wells, and, from legitimate deduction, not yet at its excess; approaching nearer the poles there is every probability of its still taking a lower station in the summer months. Lower latitudes are also found to have a smaller range of depression below the air, and the maximum in the tropics is perhaps not far from 12°. As the subject expands desirable observations rapidly become scarce, and though many reasons lead us to believe that terrestrial radiation increases on elevation, a solitary experiment alone supports it. Among a few observations at the mountain-station in Jamaica, already mentioned, one has a depression of 18°. From these statements Mr. Daniell is led to infer, "that the same cause which obstructs the passage of radiant heat in the atmosphere from the sun, opposes also its transmission from the earth into space."

Latitude then cannot be refused the first station in the diffusion of heat; as it is increased, or as the path of the sun is distanced on the surface of the earth, temperature progressively decreases. Such is the general feature of its distribution; but every spot possesses a number of circumstances continually active in modifying it. These vary so much in different places, that it becomes necessary, in estimating the temperature of any one place, to take an assemblage of circumstances into consideration which perhaps hardly occur in any other. Europe naturally becomes with us a standard for comparison as to climate with other portions of the globe; but Europe is situated among a union of favourable influences, which render its climate milder than that of any other large surface of land: hence deductions made from it will be too favourable. Besides, from the mildness of the European climate, errors are daily made as to the qualities of others; they are hastily condemned as severe and extreme, when in all probability only a fair mean of the general climates of the earth. Comparisons of this kind will establish no similarity; their chief value and importance consists in eliciting facts. Resemblances have long been sought between the northern and southern hemispheres, but every inquiry has only added fresh proofs that a different distribution of temperature takes place, such as might be expected from the relations of land and water, elevated lands, and other minor causes. The mean annual heat also does not explain what these are, nor the range of their influence; a deeper search is necessary to obtain only a small acquaintance with them.

Differences have been traced between the diffusion of heat in the old and new world. North America is a country subject to a climate of extremes; it has been described as combining a tropic summer with an arctic winter. The distribution of its heat is very different to that experienced in Europe; an estimate from the thirtieth to the sixtieth parallels gives for every ten degrees the relative proportions of 3, 9, 12, 16 in favour of the old world; this however informs us little. Dr. Mitchell during many years investigated this subject; his results announce a difference in the mean temperatures, which would require a compensation of 15° of latitude. Nothing could display more completely the futility of comparisons; it is only by a knowledge of local circumstances combined with latitude that satisfactory information can be attained useful for practical results.

II. Humidity.

On reviewing the processes continually going on in the kingdoms of nature, we cannot fail to observe an apparent vast consumption of material; but this consumption is only apparent. Following an element of a body in the state of decomposition, we shall soon find it under a new shape, and perhaps ere long again forming a constituent of a similar substance to that it first started from. The various tribes of quadrupeds, insects, and birds are constantly drawing large quantities of food from the vegetable kingdom; at first view it seems to disappear, but it is only undergoing one of the changes in the circle of its utility. Taking man as an instance: a large portion of his food is soon cast off by the respiration, by the skin, or in the excrement; the small quantity appropriated to the growth and support of the body is only detained something longer in its course. In time even his body has run its race, and when decomposition sets in, the constituents, dissolved in air, hasten to new uses; perhaps to give beauty to the gem, or strength to the pride of the forest. Again, the ore cast into the smelting furnace loses bulk and weight; escaping in an aërial torrent, and diffusing itself over the habitations of men and their fields and gardens, it is greedily seized on as the food of organized beings. Not a particle escapes, every molecule has its use; and we do not strain the truth when we assert, that since the world was made habitable for man and clothed with living things, not an atom has been added to or taken from our globe. The chemist, assisted by his noble science, can often produce surprising combinations and disunions, but is as unable to destroy or generate the smallest particle of matter, as the mechanic is to produce power.

Such reflections naturally arise on tracing Humidity through the different conditions it is destined to occupy. Its changes are developed in a circle, and wherever the investigation is commenced it will ultimately lead us back to the starting-point. It is first raised from the surface of the globe, both the aqueous and terrestrial portions, and occupies the atmosphere in an insensible state. Next, by changes occurring here, it assumes a visible form and returns to the earth as rain. Again, whilst on the earth it has to fulfil a variety of uses, furnishing all organized beings with moisture, feeding especially the vegetable kingdom with large quantities, supplying numerous lakes and rivers, and multitudes of streams in all parts of the world, the greater number of which descend to the ocean. Thus it happens that the ocean and organized matter are the last stages in its migration, and hence the chief sources of evaporation.

Humidity or moisture may then be conveniently studied under three conditions;—1st, in the state of vapour; 2nd, as rain and dew; 3rd, in its subsequent distribution on the earth.

I. The different parts of the globe, according to their structure and investments, furnish sources for the production of aqueous vapour; from the proponderance of the ocean over the dry land, and the situation of its deep gulfs and bays along the coasts of the large continents, it is undoubtedly the most fruitful source, and must be always regarded as the chief origin, of the insensible vapour suspended in the atmosphere. A vast quantity is daily absorbed when the temperature is moderately warm, for a surface with a diameter of eight inches, exposed on a summer's day, has been found to lose as much as six ounces in twenty-four hours; and when the surface becomes much increased the accumulated amount is truly surprising. After the ocean, tracts of country covered with forests yield the greatest quantity, for trees are continually taking up and giving out moisture, and the amount they contribute will be in proportion to the luxuriance of the vegetation, the temperature being the same. When the condition of a territory is such as to yield little or no vegetation, the vapour it contributes to the atmosphere is very trifling, and in some of the herbless tracts and deserts it would be a difficult task to appreciate the very small portion resigned. The excessive aridity of the air over the African deserts has been a source of great annoyance to travellers, who complain of the dryness and roughness of the skin occasioned by it, and also of a very sensibly increased thirst from the rapid transpiration in an atmosphere greedy of moisture.

Owing to evaporation, the extremes of temperature are modified to favourable conditions; great heats are kept under by the quantity of caloric becoming latent in the transition from the sensible to the insensible state; and lest such an enormous evaporation should take place to disturb the proper equilibrium in nature, it has been so ordered, that in proportion as the air becomes loaded with vapour, vaporization proceeds with less energy. In the extremes of low temperature the former circumstances become reversed, and are thus a further compensation; when the temperature is sufficiently depressed the insensible moisture is precipitated, and the caloric necessary to its existence as an aëriform body is given out and becomes sensible.

The relative proportion of moisture in the atmosphere varies with circumstances; temperature has a powerful influence over the quantity suspended, and a change in the amount occurs as the temperature alters through the seasons. Alterations of temperature in small intervals of time have but a trifling effect, and it is rather the mean heat of a reasonable portion that it follows. Between the conditions of the vapour of the atmosphere and the circumstances of evaporation there are such points of resemblance, that an estimate of one puts us in possession of the chief features of the other. The mean temperatures have been seen to advance as the latitude is diminished, or as the equator is approached, and the activity of evaporation and the quantity of suspended vapour proportionately increase from the poles to the equator. The higher the mean temperature, other things being the same, the greater is the force of evaporation, and necessarily the quantity of moisture suspended in the air.

Not many data have hitherto been obtained as to the amount of evaporation in different latitudes, or under a variety of mean temperatures. To supply this deficiency a table has been calculated for the rate of evaporation for every 5° from the equator to the pole; it has been constructed on the admission that the deposition of moisture takes place in England at 6° below the mean temperature. It is not improbable that the mean point of deposition below the mean temperature varies very little in different latitudes, and that a depression of 6° below the mean will be nearly as correct for the tropics as for our own climate.

Latitude.	Mean Temp.	Evaporation in inches.		Difference in the Yearly Evaporation.	Latitude.	Mean Temp.	Evaporation in inches.		Difference in the Yearly Evaporation.
		Daily.	Yearly.				Daily.	Yearly.	
0	85°	·18938	69·10		50	53°·3	·07312	26·71	4·18
5	84·6	·18717	68 32	·78	55	48·8	·06327	23·09	3·62
10	83·4	·18085	66·01	2·31	60	44·5	·05517	20·14	2·95
15	81·4	·17073	62·32	3·69	65	40·6	·04860	17·74	2·40
20	78·7	·15786	57·62	4·70	70	37·3	·04362	15·92	1·82
25	75·4	.14133	52·32	5·30	75	34·6	·03990	14·56	1·36
30	71·5	·12769	46·61	5·71	80	32·6	·03732	12·62	·94
35	67·2	·11222	40·96	5·65	85	31·4	·03584	13·09	·53
40	62·7	·09785	35·72	5·24	90	31	·03537	12·91	·18
45	58	·08463	30·89	4·83					

This table is theoretical, and constructed on the foundation of one solitary observed fact, for a variety of situations where the progression is by no means regular; it can only be regarded as an approximation, in the absence of regular observations. Several remarks might be elicited by it, but it will be sufficient to place by its side a few observed results on the same subject.

At Cumana....	Lat. N.	10° 28′	the annual evaporation is	100	inches.
Guadaloupe	„	15 59	„	97	„
Toulon......	„	43 7	„	40	„
Paris........	„	48 50	„	32	„
London ...	„	51 31	„	24	„

I am especially desirous of drawing a line between the theoretical deductions of the closet and the real practical results of observations. Without disparaging the labours of those who have devoted their time and abilities to the construction of theoretical tables, we must add, that a close adherence to them is more likely to lead to false than correct conclusions. There is a "fatal facility" about the formation of some of them in leading us to important conclusions, that it is not surprising we have tables for mean temperatures, and the annual amounts of evaporation, rain, &c., for every latitude from the equator to the poles, in many of which we are greatly deficient in any practical observations whatever. The use of them consists in offering approximations to what is the real condition of the subject when observations are wanting, and this is their chief advantage; no modifying circumstances are taken into consideration, yet in the case of rain we can select a parallel of latitude where in one part of it rain never falls, and in another a dry day is an unusual luxury. It cannot even be allowed that some of these tables furnish a correct mean for any given latitude, after setting aside all those circumstances which are continually combating a regular progression. If they did so far unfold circumstances they would prove of the greatest possible use, as henceforth every modifying agent could have its proper value applied.

In England some pains have been taken to estimate the amount of evaporation during the different months of the year, and to discover their several evaporating powers. Mr. Hoyle and Mr. Dalton used a method which is perhaps as little objectionable as any for this purpose is likely to be; it is thus described:—"A cylindrical vessel of tinned iron, ten inches in diameter and three feet deep, having tubes soldered to it for conveying off into bottles the water which is received, was buried in the ground in an open situation, and then filled with gravel, sand and soil; the whole being covered with grass and other vegetables, it was allowed to receive the rain, and to suffer evaporation from the surface as in ordinary circumstances. A register was kept of the quantity which made its way through the soil into the bottles; and a rain-gauge of equal surface was placed close by for the sake of comparison." The results obtained by this instrument are given in the following table.

Month.	Water through the two Pipes in			Mean.	Mean Rain.	Mean evaporation from Ground.	Mean evaporation from Water.
	1796.	1797.	1798.				
January	1·90	·68	1·77	1·45	2·46	1·01	1·50
February ...	1·78	·92	1·12	1·27	1·80	·53	2·00
March	·43	·07	·34	·28	·90	·62	3·50
April	·22	·30	·18	·23	1·72	1·49	4·50
May	2·03	2·44	·01	1·49	4·18	2·69	4·96
June	·17	·73	—	·30	2·48	2·18	4·49
July	·15	·03	—	·06	4·15	4·09	5·63
August			·50	·17	3·55	3·38	6·06
September ...		·98		·33	3·28	2·95	3·90
October		·68		·23	2·90	2·67	2·35
November ...		1·04	1·59	·88	2·93	2·05	2·04
December ...	·20	3·08	1·88	1·72	3·20	1·48	1·50
	6·88	10·95	7·39	8·41	33·55	25·14	44·43
Rain	30·63	38·79	31·26				
Evaporation	23·75	27·84	23·87				

The figures express the quantities in inches and hundredths; in the first three columns the amount of the water found in the bottles attached to the cylinder is expressed; deducting this from the rain found in the gauge, the remainder becomes the quantity evaporated. The next three columns contain means which are interesting sources of comparison; for the same reason the last column is also valuable, as enabling us to compare a surface of water unprotected by covering with the condition of the water in the experiment.

Raised from the earth by evaporation, the aqueous vapour mixes with the atmosphere and becomes henceforth a constituent portion; its existence here is entirely dependent on the presence of a certain temperature, and the higher this is, the greater will be the quantity of moisture found suspended: hence occurs, from the equator to the poles, a progressive decrease of the aqueous vapour. The circumstance observed here on a large scale also happens with the progression of the seasons: as the temperature fluctuates the atmosphere holds in solution a greater or less quantity of vapour; changes occurring rapidly in short periods of time are not what affect it so much as the general mean of the season, of the month, or even of the day. In the latter months of our summer a good deal of rain falls, and this is greater as the previous weather has been warm, and the air become saturated with moisture; the heat of the summer has favoured the absorption of an unusual quantity of aqueous vapour, and ultimately the air becomes so saturated that a small decrease of temperature produces precipitation.

The quantity of vapour dissolved in the atmosphere from the equator to high latitudes is very regular in its progression, and we are fortunate in being enabled to maintain this position by a reference to an extensive series of observations, in the Appendix to Beechey's 'Voyage,' from a small portion of which the next table has been compiled. A period has been selected when the continuity of the observations was very little broken, and which embraced high latitudes in both hemispheres; the whole were obtained in the Pacific Ocean.

Date.	Latitude.	Temperature of Air.	Dew-point.	Weight of Vapour in a cubic foot of Air.	Winds.
				grains.	
Sept. 25 to Sept. 29	55°—50° S.	42°·6	36°·7	2·9141	Westerly
Sept. 30 to Oct. 1	50—45	45·8	44·	3·7365	and
Oct. 2 to Oct. 3	45—40	49·48	Precipitation.		South-west.
Oct. 4 to Oct. 8	40—35	53·31	47·	4·0767	...
Nov. 1 to Nov. 6	35—30	62·59	53·6	5·0368	Southerly.
Nov. 7 to Nov. 24	30—25	69·8	65·6	7·2185	...
Nov. 25 to Dec. 5	25—20	74·5	71·9	8·8272	S.E. trade.
Feb. 1 to April 25	20—15	80·21	77·9	10·4883	...
April 26 to May 1	15—10	81·34	78·4	10·3293	...
May 2 to May 5	10— 5	82·60	79·8	9·6099	...
May 6 to May 8	5— 0	80·9	78·5	10·9278	...
May 9 to May 11	0— 5N.	80·24	79·	10·9945	...
May 12 to May 14	5—10	78·85	78·	10·6745	...
May 15 to May 16	10—15	78·97	75·5	9·8837	N.E. trade.
May 17 to May 18	15—20	78·2	73·	9·2363	...
May 19	Sandwich Is.	77·29	70·5	8·1921	...
June 3 to June 12	25—30	75·49	66·3	9·3803	...
June 13 to June 18	30—35	70·82	67·7	7·3920	...
June 19 to June 21	35—40	73·27	70·5	8·5171	Variable.
June 22 to June 24	40—45	56·33	59·	6·6082	...
June 25 to June 27	45—50	45·12	45·	3·7480	...
July 6 to July 11	50—55	47·10	47·4	4·1933	...
July 12 to July 15	55—60	45·97	46·5	4·0713	...
July 16 to July 19	60—65	43·52	43·6	3·6972	...
Aug. 19 to Aug. 26	65—70	40·01	38·7	3·1634	West.

These results are obtained from a number of daily observations, meaned to every 5° of latitude, from which the weight of vapour has been calculated. The whole of the details offer much material for comparison; they include a period of four years, and comprehend an extensive range of the Atlantic and Pacific Oceans, with numerous ports and harbours on their coasts. On running the eye over the column containing the weight of vapour, it is not a little surprising to see the regularity with which the amount of the atmospheric moisture increases on approaching the equator. From the high latitudes of both hemispheres the same occurs, nor can we perceive that the trades make any notable difference. The value of this table over the manufacture of the closet is immense; here we have a set of results such as they really were at a certain period of the year, and in every probability conducted with such a regard to correctness that implicit confidence can be placed in them. Such numerous details induce us to draw comparisons between the circumstances of humidity in the two oceans, and one at the equator will be among the most interesting.

	Temp.	Dew-point.	Grains.
Atlantic, June	79°·6	73°	9·8560
Pacific, May	80·24	79	10·9945
,, April	79	75	9·8550

The two first are from Captain Beechey, and are his means for 5° north of the equator; the latter I observed myself within a few miles of the equator some ten years afterwards. As it was not unlikely that further comparisons might show me some practical results of the influence of the seasons, I selected another parallel, but only for the reasons that it was frequently traversed, and that it approached closely the latitude of England. Like the former, they are a set of means for a series of 5° in the North Pacific Ocean between 50° and 55°. The similarity in the months and the difference in the seasons are marked.

	Temp.	Dew-point.	Grains.
1826 July	47·10	47·4	4·1933
,, October	44·9	40·7	2·4131
1827 July	49·12	48·1	4·0161
,, October	40·36	35·	2·7697

The atmosphere over such a surface as the ocean may reasonably be considered as having more aqueous vapour in solution than will be found elsewhere in the same latitude, and on this account the observations for any particular spot may be regarded as nearly the excess for that season of the year. The humidity of the air over the ocean being so great, every wind which blows from it towards the land carries with it a quantity of vapour; and wherever sea-breezes blow over elevated land, this is rendered visible; for the atmosphere, previously clear and transparent, becomes on its accession obscured with light clouds, and the surface of the high land supports wreaths of them which increase during its continuance. The aspects exposed to those refreshing winds, the Trades, display a superiority in their vegetable productions, arising from the moisture they are constantly conveying; the group of islands called the Galapagos, notwithstanding their position, are not remarkable for fertility, but those situations exposed to the trade-wind surpass the other parts of the islands in the vigour of their vegetation.

For some time it was an admitted circumstance, that the quantity of aqueous vapour diminished in a regular progression from the earth upwards. But Mr. Daniell was led, first of all, he tells us, by theory, and subsequently by direct experiment, to consider that this was not the real state of its suspension. The chief experiments on which he founds his conclusions were made in an aëronautic voyage in the month of September. On attaining an elevation of 9890 feet the dew-point was exactly the same as at the surface of the earth; and on ascending 1100 feet higher, the dew-point had fallen thirty-two degrees. Some further observations were made at elevations, the greatest little more than half the height of this, and as none of them reached the point of sudden depression, they are destitute of the chief part of their interest. Considering this as the correct view of its conditions, we have nothing to add as to the circumstances connected with its regular diffusion.

II. The aqueous vapour of the atmosphere is continually meeting with circumstances which disturb its suspension; depressions of temperature are of course the most usual, and will be frequent in proportion as it approaches saturation. It is evident that changes of temperature occurring near the surface of the earth are soon propagated through the atmosphere, as is shown in some of the causes influencing the formation of dew. Howard was of opinion that rain was generally produced by electrical action, and many of the instances which externally seem to produce rain by decreasing the temperature, are capable of being attributed to alterations in the electrical conditions. On the contrary, dews are deposited solely by wanting a sufficient temperature to maintain their suspension. The agents influencing this, and the circumstances attending the deposition, are among the most interesting, and associated by all with the name of Dr. Wells. It has been shown that the diminution of temperature has not its origin in the air, since by terrestrial radiation the different substances on the surface of the earth become cooled below the atmosphere, and as portions of it come in contact, they part with that moisture which the diminished temperature does not permit them to suspend. These two modes of precipitation will be best considered separately.

1. Rain falls in proportions having such a relation with the latitude that the circumstances of the latter considerably affect it; but local causes have a great influence over the amount. In countries situated in high latitudes and composed of high lands, the amount of rain and rainy days is great. In the mountainous districts of the north of our island rainy days are very numerous, and in some parts of Norway they are still more so. About Cape Horn, Staten Land, and the islands of the surrounding seas, the number of rainy days is very great, and it is rare to see a day on which some rain does not fall. At Sitka or New Archangel, the prevalence of rainy weather is such, that a Russian officer is induced to say there is perhaps not a spot on the whole earth where so much rain falls; a dry day, he adds, is a perfect rarity. I have been enabled to form an opinion of this delectable climate, and during a visit the rainy days were to the fine as thirteen to three, and this the residents regarded as unusually fine weather. Mountainous countries generally are favourable to the fall of rain, particularly in high latitudes; and we are not surprised at this, knowing that the progressive decrease of temperature occurs more rapidly for given heights than in lower ones. Our own island does not contain any very great mountain ranges, but those we have influence the quantity of rain; at Kendal, where the surrounding land is elevated, observations through twenty years give the mean annual fall of rain as 53·94 inches, and in London, for a period of forty years, the annual rain was only 20·68 inches.

In low latitudes also there are instances of almost constant rains. On the coast of Africa, between 4° and 10° N. lat., there is a range of surface which, from local causes, is subject to variable winds and very frequent storms and showers, on which account it has been called 'The Rains.' In a similar latitude on the west coast of South America is the Bay of Choco; here for ten months of the year rain falls almost daily, leaving vegetation a short repose of two months of dry weather; the flora of this region is unsurpassed for its denseness and magnificence.

A reversed condition of climate as to rain is equally prevalent; in many places and districts a rainy day would be looked on as a novelty and a blessing, whilst there are others where the habits and customs of the people are so directed by its absence, that a heavy shower would completely disconcert them, and bring incalculable mischief. In some parts of the world are extensive level surfaces removed from the ocean, and left by nature destiture of moisture; over them the atmosphere is dry to an extreme, and they are free from changes of temperature, cold winds, or currents of air; as instances may be mentioned the large deserts, as those of Africa, Egypt and Arabia, and the great central desert of Asia. The sandy plains or karroos, which stretch to the north from the Cape of Good Hope, rarely witness rains, whilst so greedy are they of moisture, that rivers are absorbed by their sands.

Exposure to a wind constantly blowing from one direction is another source of freedom from rain; in the trade-winds rain is said to be seldom seen, they being usually regarded as having a tolerable exemption. Though rain is certainly not so frequent here as elsewhere, yet, in crossing the trades at several different periods, I have generally witnessed occasional showers, and these sometimes heavy, whilst they also occur more commonly in the night. They are more frequent in the Pacific than in the Atlantic Ocean, and when prevailing, the force of the breeze will be observed to fluctuate a good deal. To the same cause is attributable that remarkable absence of rain from a surface of territory in Peru, of which Lima forms a portion: the *garuas* which supply the soil and vegetation with moisture resemble dense mists; during the night and early part of the day they fall heavily, and a person exposed to them is soon thoroughly wetted, whilst they convey much chilliness to the feelings. This fine precipitation of moisture sometimes borders very closely on fine rain; it commences about 2 A.M., and is often very heavy early in the morning; perhaps during the day the sun succeeds in penetrating it, but this is by no means always the case. This kind of weather continues from May to August, and the thermometer ranges from 60° to 70°, which is cold and chilly compared with the remainder of the year. Instead of the garuas, were the city of Lima to be visited for any length of time by the rains usual in its latitude, many of the buildings would be completely destroyed; for aware that they are not subject to rains, the inhabitants occupy houses built of a material very like hardened mud, and all the houses being flat-topped would retain much of the rain that fell. So great indeed is the usual torrent of rain in the tropics, that in those towns exposed to them the houses are supplied with a number of shoots to carry off the water with all possible speed; and as it often happens that these are decorated with fantastic colours, the perspective of the streets is unique to a foreigner. Ulloa has laboured to prove that the rarity of rain in the region of the garuas is attributable to the constancy of the south wind. At the season of the year, he observes, when the garuas prevail, a very light north wind is frequent*. Thunder and lightning are equally rare with the rain. The extent of country subject to these features lies between the Cordilleras and the coast, to the north is limited by the bay of Guayaquil, or 4° S. lat., and to the south extends through Peru into Chili; in the latter it gradually merges into the climate of the latitude, but even at Valparaiso its influence has not entirely ceased; for though this place has its rainy season, it is of short duration, and the dews are exceedingly heavy.

Within the limits of the garuas there is a remarkable absence of the larger vegetation; trees in a natural state are rare, the usual woody plants being bushes; I do not mean to trace any connexion between the two, for I could never discover any—it is merely a coincidence. Even at Valparaiso, the only trees to be seen growing, as planted by nature, are a few of *Cocos Chilensis* in some of the more sheltered valleys. That large trees will grow is very evident from the number of fruit-trees in many places, and from the fine avenues which shade the roads and promenades about Lima; still this tract of coast, it must be allowed, has been left by nature adendrous.

The atmosphere of the trades is so nearly saturated, that slight circumstances are sufficient to cause a precipitation; frequently the groups of islands in their influence can produce such a depression as to bring on heavy showers; but islands in the trades are not usually exposed to much rainy weather. In one of the group of the Sandwich Islands, I was able to witness the gradual formation of clouds and rain after a long interval of dry weather; the breeze blew rather on the end of the island and over its whole length, which is intersected by a number of beautiful valleys; the most elevated portion was to windward, and around this light vapours collected, gradually thickening into clouds, which, swept by the breeze over the mountain heights, soon became too heavy for suspension, and fell in heavy but partial showers; so that whilst one portion of a lovely valley was glowing under the full blaze of the sun, another was drenched in rain. It was curious to observe how very regularly the deposition increased to leeward; the valleys in this direction received a good deal more rain than those more to windward, and are looked on as proportionately more fertile, and property in them is more valuable. As the circumstance was soon very evident, it became of practical importance in making botanizing excursions, and a look at the weather and the summit of the island de-

* Ulloa, Voyage to South America, vol. ii. p. 67.

termined whether the day was to be spent in the valleys to leeward or to windward. But even in this group the islands have peculiarities confined to each; though rain had been rare on the above island, Oahu, on visiting shortly after the island of Taui, we learnt that for the last six months, in one part of it, not a single day had occurred without some rain. In all of the islands the vegetation is rich and fascinating, but the portion of Taui subject to such plentiful rains surpasses the others.

Another instance of the rare occurrence of rain is mentioned by Sir Francis Head as taking place at Uspallata, but is not to be easily accounted for. Uspallata is famed for its silver-mines, and is also the last inhabited station on the eastern side of the Cordilleras, on the Mendoza road; around is nothing but desolation and barrenness; those who have lived there never saw rain, and other facts are mentioned showing its usual absence.

Notwithstanding these illustrations, the fall of rain in most countries has a relation to the latitude, and decreases in amount as we recede from the equator. The manner in which this occurs will be best seen in a tabular form.

Place.	Latitude.	Mean Temperature.	Rain in inches.	No. of days on which rain fell.
Para	° ′ 1 28N.	° 84	80	...
Ceylon . . .	8 32 „	......	84·3	...
Cumana . . .	10 28 „	81·2	8	...
Grenada Island .	12 3 „	......	112	...
St. Domingo . .	18 30 „	......	150	...
Vera Cruz . .	19 12 „	77·7	63·8	...
Calcutta . . .	22 34 „	......	81	...
Madeira . . .	32 37 „	65	31	73
New South Wales	33 51 S.	70·6	......	107
Rome	41 54N.	59·5	39	117
Pisa	43 43 „	......	45·6	...
Florence . . .	43 47 „	......	31·6	103
Venice . . .	45 26 „	......	36	...
Columbia River	45 30 „	54	53·6	157
Great St. Bernard	46 „	......	63	...
Geneva . . .	46 12 „	50	42·6	...
Paris	48 50 „	51·9	19·9	...
Reading . . .	51 27 „	51·5	22·9	123
London . . .	51 31 „	50·4	22·7	178
Berlin . . .	52 32 „	......	20·6	...
Carlisle . . .	54 54 „	......	34·32	234
Kinfawns . .	56 23 „	46·8	25·6	201
Upsal	59 52 „	42	16	...
St. Petersburg .	59 56 „	38·8	16·17	...
Ullaborg . . .	65 3 „	33	13·5	...

Between the amount of evaporation and precipitation there is necessarily a considerable connexion; this is observable in the quantity of rain in different latitudes, and again in our own climate, where more rain falls in the warm than in the cold seasons; towards the end of our summer the amount is greatest; and of two summers, one cold and the other conspicuous for its warmth, the latter closes with most rain. No regular proportion exists between the number of rainy days and the quantity of rain. In noting the rainy days of a climate, it is usual to enumerate every day of the year on which even a slight shower has been observed. The number of days on which rain falls depends much on the range of temperature which takes place in short intervals of time, particularly in extra-tropical latitudes, and if the atmosphere receives its moisture from the ocean, the number will be much increased. These days are more numerous as we advance to high latitudes, and are thus inversely to the amount of rain. In the table the general progression of both is visible.

There is a feature in the fall of rain, which, though intimately connected with elevation, we do not think is very likely to influence alpine vegetation; yet as it may in some cases contribute to account for any peculiarities this variety of flora may possess, we cannot pass it over without some notice; to the meteorologist it is of greater interest. Many years since it was ascertained, that if rain was collected at different elevations in the same perpendicular, a difference in the amount would be observed; that the portion nearest the surface would be greatest, and on increasing the height a gradual diminution would take place. Experiments were made at several places, and all with the same results. The Hon. Daines Barrington measured the quantity in Wales between the base and summit of a mountain 1850 feet high; in four months 8·766 inches had fallen below, and on the height 8·165 inches. Dr. Heberden obtained the same results, but in more decided proportions; and more recently some observations have been conducted at York by Messrs. Gray and Phillips, which give the amount at three separate heights. The particular situation of the observations, height and quantity of rain, are as follows:—

Top of Minster, elevated	242	feet,	15·715	inches.
Top of Museum,	„ 73	„	20·182	„
Grounds of Museum	„ 29	„	23·785	„

To account for this increase, it has been advanced, that the drops of rain in their descent, owing to their lower temperature, condense around them the aqueous vapour in the atmosphere through which they pass.

In speaking of the effects of cultivation on the temperature, its influence on the production of rain has been in some measure anticipated; wherever large tracts have been cleared of forests, as in the United States, some parts of the Canadas, and the West India islands, the quantity of rain has materially diminished. From two causes vegetation favours the formation of rain, by supplying an abundance of moisture, and increasing the daily range in the temperature; as an instance of the increase of rain, the island of Ascension has been mentioned, where the introduction of a trifling extent of cultivation has perceptibly increased the deposition.

2. That depression of temperature which gives rise to the formation of dew is produced by terrestrial radiation; substances radiate with varying intensity according to their structure and colours, and of all, none has been found to radiate so freely as the green parts of plants; they are hence well provided with the means of supplying themselves with moisture. Dews are of the greatest importance to vegetation, particularly in those situations where rain is rare, or falls copiously only in one season; during the dry seasons of low latitudes, it is to them that vegetation is indebted chiefly for moisture. Whilst the sun is absent plants imbibe it freely, and by this change of action a period of repose is allowed to vegetation, which may be compared to a man who gives rest to one set of muscles by putting another into activity.

In our climate the amount of moisture which falls as dew has been estimated as equal to five inches, and the quantity is considerably greater in lower parallels. The excess of deposition occurs in those climates which have long dry seasons, and, judging from appearances, the quantity here must be very great. Its good effects on vegetation are not entirely in proportion to the quantity, but more to the gradual and perfect manner in which small portions are applied at intervals to the organs after the exhaustion of a burning sun. In the morning, when the full nocturnal amount has been precipitated, every substance is covered with pearls of moisture; the trees drip as after a heavy shower; so completely is the dusty surface of the roads moistened, that a water-cart seems to have passed over them, and all the smaller vegetation is laden with drops of dew. As the sun rises all this soon vanishes; but whether resumed by the atmosphere again, or, aided in energy by the light and heat, the vegetation absorbs it, is, I think, doubtful. Dew commences to form soon after sunset, and sometimes, when the air is well saturated, even before; it continues progressively through the night, accompanying the gradual diminution of temperature, and occasionally till after sunrise, but at this time decreasing in quantity. That more dew falls on clear, calm nights than under opposite circumstances, is as old an observation as the days of Aristotle, though he was unable to account for it with the correct yet curious intricacy of the present day. A still state of the atmosphere favours the terrestrial radiation in which dews originate; breezes of wind disturb the formation: thus, in spots which are sheltered, dew forms with most rapidity and freedom.

A small diminution of temperature is sufficient for the existence of dew; hence most substances are capable of appropriating some to themselves during the night. Vegetation surpasses all others in the depression it is capable of producing; with us this can be observed from 10° to 20° below the temperature of the air, and in the tropics it is still greater. When the atmosphere is for the time so constituted that some of the bodies on the surface of the earth cannot radiate sufficiently to attach dew, whilst others are covered with a thin film, the different substances become so many indices of their respective powers in facilitating deposition, and it is not difficult to appreciate the different shades of their radiating properties in this way.

Not only is vegetation within the tropics dependent on dew for a large proportion of its moisture, but in all latitudes it is the same; it is here perhaps that the most visible effects are seen; and, before the heat of the day plants exhibit much vigour and freshness; yet beyond the tropics, and in those bright latitudes where clear blue skies prevail, the dews are also intense. In California and Chili, countries in similar situations in each hemisphere, a person exposed to the dews soon becomes as wet as after a shower of rain; it is late in the day in the latter before the sun has obliterated the dew of the previous night. The soil in sheltered situations seems to retain a perennial moisture, and the rains are rare and of short continuance.

III. Moisture is so great a blessing to the earth, that nature everywhere acknowledges its beneficial properties; and those parts of the world without it are so dreary and desolate as to be totally unfitted for the habitation of man, and even for the existence of animated beings or plants. The large desert tracts which cover occasional portions of the earth, without water, are rendered so thoroughly destitute of life, that not an insect occupies the air or an animal lives on the surface; man alone, urged by the love of gain, hastily traverses them, taking with him every necessary for the support of life. Yet perhaps there are few situations which, with a plentiful supply of moisture, would not support a vegetation: much of the coast of Chili and Peru has not a plant on it; the soil is further rendered ungenial by a copious admixture of nitre and muriate of soda; a few valleys alone intersect the surface, carrying a stream or a river to the ocean, but here often is a lively vegetation.

The activity of man has in some measure compensated for the sterility of nature; large districts have been subjected to a methodical and well-regulated irrigation, and rendered capable of bearing crops and fruits; in Egypt irrigation was in former times carried to a considerable extent, as it is in many parts of the world at the present day. Some plants require a certain submersion for their growth: rice, which of the various grains supports the greatest portion of mankind, requires this either by natural or artificial means; and with *Caladium esculentum*, the root of which is the taro and staple food of the Pacific islanders, it is the same.

Estimates have been made as to the various ways in which the moisture which falls on the land has been appropriated; these are sometimes very vague, and disagree among themselves. In this manner it has been stated that evaporation again removes a fifth part, and that vegetation disposes of another fifth, the three remaining being carried off in a fluid form by streams and rivers. These proportions do not agree with what has been advanced respecting the relative amount of rain, dew, and evaporation in different latitudes, and we are further assured of their slender claims to correctness on finding one person stating the quantity passing off by rivers in England to be equal to four inches, and another authority fixing it at thirteen. An important part of the water which finds its way into rivers is still destined to administer to the wants of vegetation. In those hot climates where most of the large rivers are found, they periodically overflow their banks and inundate the adjoining plains; no rain may fall anywhere near these parts of the rivers, which are usually in the neighbourhood of the mouth, but at great distances, frequently among the mountainous countries whence they take their origin, as is the case with the Nile in a remarkable degree, and with the Ganges. The natives residing near their banks are eminently alive to the great benefit conferred on their cultivated grounds by the rising of the waters, and frequently regard the river, especially at the period of its swelling, with much reverence and religious awe. Large quantities of vegetable substances in different stages of decomposition are swept down in the increasing current, and, spreading over the surface of the submersed country, are left behind on the subsiding of the river.

Frequently the water itself is supposed to contain nutritive qualities, which, though not distinguishable to the eye or taste, are unquestionable from the superior luxuriance of the subsequent vegetation. It is not improbable that vegetable matter may become so mixed up in the water of some of these rivers, as not to be perceptible to ordinary examination. It must be remembered that they often take their rise in high and mountainous regions, and have to pursue a course to the ocean sometimes of thousands of miles, continually deflected from the straight course by chains of hills, falling in frequent cascades, tumbling over huge rocks, and boiling in eddies and whirlpools. A dense vegetation covers the country through which they roll, and overhangs its banks; trees, undermined or falling through age, are precipitated into the stream; the large sear leaves of the autumn of a tropic forest are wafted there by every breeze, and before they find their way to the ocean much has become comminuted and dissolved. It is easy then to account for the luxuriant vegetation on the banks of the Ganges, Niger, Amazon, and similar rivers, and to appreciate the vast fertility which their overflowing waters carry with them, and the misery and sterility consequent on a sparing wet season.

Vegetation is capable of appropriating a large quantity of moisture, particularly in the active stages of its growth: numerous experiments have been made to ascertain the amount a plant will take up; in one of these, by Hales, a pear-tree weighing 71 lbs. was allowed to imbibe as much moisture as it was able for the space of six hours, when it was found that fifteen pounds of water had disappeared. It is interesting to observe how very much the parts of plants are fashioned according to the kind of climate they are destined to live under: in the tropics, where the climate is warm and moist, plants are clothed with large flaccid leaves in great numbers, and flowers are not very abundant in this variety; if the air is warm and tending to dryness the foliage is much smaller; Leguminosæ and their compound leaves prevail, and the structure is leathery and dry. Very peculiar is the vegetation of a country eminent for dryness: its plants are adapted in their organization to the circumstances around them; the leaves are provided with comparatively few stomata or evaporating pores, and are so many magazines of moisture; the leaves are also small in size, or if large, cut and divided, to offer the more surface for absorption. The flora of the Cape of Good Hope is very peculiar, and has much of this character; among its numerous bulbous and succulent plants, heaths, and Proteaceæ, the features of its climate are easily read. I have chanced to see the vegetation from the equator to high latitudes in both hemispheres under some variety of circumstances, and the only families of plants which I could perceive followed humidity through many different parallels were Hepaticæ and Lichens; from the moist pine-forests of the north to the warm sunny clime of the equator, wherever the atmosphere is humid, these abound. In the former, the surface of the large vegetation, the soil, and denuded rocks have each their investment; whilst in the latter it is the trunks of the trees chiefly which support many brilliant and fascinating species.

[To be continued.]

XXXVII.—*On the Conferva which vegetates on the skin of the Gold-fish.* By John Goodsir, Conservator of the Museum of the Royal College of Surgeons in Edinburgh*.

Lady Brisbane having observed that a gold-fish which had lived for some time in a glass vase presented a very unusual appearance, as if a quantity of cotton were attached to its dorsal fin and tail, requested Mr. Bryson to explain the circumstance. That gentleman, having seen in the 'Microscopic Journal' a notice of the occurrence of vegetables parasitic on living animals †, at once suspected that the cotton-like substance was a plant. Lady Brisbane kindly allowed him to remove the fish to Edinburgh for more accurate examination. Mr. Bryson sent it to me, with the information that the peculiar substance had made its appearance on the animal six weeks before.

The fish had been conveyed to town in a jug of water, but had died on the journey, so that I lost the opportunity of observing the parasite during the life of the animal. The water had begun to be tinged with blood and colouring matter from incipient putrefaction. The results of the examination were not, therefore, so satisfactory as I could have wished.

The parasite, when examined under water, presented to the naked eye a continuous mass consisting of minute filaments about three-quarters of an inch in length, and extending all along the dorsal and posterior edge of the tail-fins. The filaments, although individually transparent, were so close to one another and so numerous, that the mass appeared opake. When the lateral portions of the mass were separated along the median line, so as to display the free edges of the fins,

* Read before the Botanical Society of Edinburgh, Jan. 13, 1842.

† See Ann. and Mag. Nat. Hist., vol. viii. p. 229, and p. 10 of this volume.—Ed.